B21 cont.

necessary to enable the vessel to pass the deformation test at 10,000 psi. It was the strongest standard tubing that was conveniently available. The cap was made of the same material. Thermal expansion was matched to that of the tubular casing in that way. Other materials could be used but at additional expense.

REMARKS

Claims 3-4 and 9-20 remain in this application. Applicants filed an amendment dated July 10, 2002 in response to the First Office Action of April 10, 2002. This supplemental amendment is submitted to correct minor errors in the drawings and specification. Entry of this amendment prior to re-examination is respectfully requested.

Claims 3 and 4 are amended to provide an antecedent basis for the phrase "hollow interior".

Permission to amend the drawings is requested to correct a number of minor mistakes relating to reference numbers being incorrect or missing. Brackets are being added to Figures 6 and 7 to make them consistent with Figure 5.

In light of the above amendments and remarks applicants believe that this case is in good condition for allowance, and respectfully requests that it be passed to issue.

If a telephone or further personal conference would be helpful, the Examiner is invited to call the undersigned, who will cooperate in any appropriate manner to advance prosecution.

I hereby certify that this correspondence is being sent via facsimile and is being deposited with the United States Postal Service as First Class mail in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231 on August 14, 2002. By: Marc Fregoso Marc Fregoso Signature Date: August 14, 2002	Respectfully submitted, PRICE AND GESS Albin H. Gess Albin H. Gess Registration No. 25,726 2100 S.E. Main Street, Suite 250 Irvine, California 92614 Telephone: (949) 261-8433

<u>VERSION WITH MARKINGS TO SHOW CHANGES MADE</u>

<u>IN THE CLAIMS</u>

Claims 3 and 4 have been amended as follows.

3. (Twice Amended) An improved pressure vessel comprising:

a tubular casing having an internal cavity and an opening in at least one end permitting access to said internal cavity;

a plug region <u>followed by a hollow interior, the plug region being</u> adjacent said opening with a plug therein, the plug and plug region having a cross section diminishing in diameter with distance from the opening; and,

a component in said hollow interior having at least a first lead passing through said plug to exit the pressure vessel, said plug encapsulating said component lead and sealing said opening.

4. (Twice Amended) An improved pressure vessel comprising:

a tubular casing having an internal cavity with a circular cross section and an opening in at least one end permitting access to said internal cavity;

a plug region adjacent said opening with a plug therein, the plug region being necked down to match the internal cavity circular cross section; <u>the internal cavity having a hollow region adjacent the plug region</u> and,

a component in [said] <u>the</u> hollow interior having at least a first lead passing through said plug to exit the pressure vessel, said plug encapsulating said component lead and sealing said opening.

<u>IN THE SPECIFICATION</u>

The paragraph beginning on page 1, line 12, has been amended as follows.

Pressure vessels presently designed for [Oceanographic] <u>oceanographic</u> research under conditions of high hydrostatic pressure typically employ O-ring seals. Such seals are conventionally "piston" type or "compression" type seals. Such vessels have been employed to reach ocean depths such [as the] as the Mariana's Trench which is 36,000 feet deep. At such depths pressures of 18,000 psi must be accommodated. [The present application] <u>The design of the subject pressure vessel</u> required that the pressure vessel

withstand pressures in an oil well drill hole of 10,000 psi but with the added requirement of temperatures that reached 200 degrees centigrade. The package was required to protect an optical component at these temperatures. Fiber optic leads from the components had to be protected and permitted to extend through openings in the package.

The paragraph beginning on page 2, line 30, has been amended as follows.

Figure 1 is a schematic drawing of an interferometer 2 such as a Mach Zhender interferometer, such as might be used in a hydrophone or sonar array for the detection of acoustical information. Such sensors are among the most sensitive known. Figure [shows] 2 shows the interferometer connected between a pair of optical couplers 4, 6 as a segment of a hydrophone array. Figure 3 shows the segment of the array positioned within a flexible tube or hose 8. The tube 8 would typically house many other segments (not shown) and might also carry a number <u>of</u> interconnecting optical fibers, electrical conductors, optical components such as optical amplifiers.

The paragraph beginning on page 3, line 7, has been amended as follows.

The hose 8 might be deployed in a drill hole for oil [that might be thousands of] <u>that is potentially thousands of</u> feet in length or towed behind a ship or deployed as a stationary array on the bottom of a sector of the ocean. In each such application, the optical and electronic components within the hose must be protected from extremes of hydrostatic or hydraulic pressures and in the case of down hole applications, from high temperatures approaching 200 degree centigrade.

The paragraph beginning on page 3, line 13, as been amended as follows.

Figure 4 is an elevation view of the pressure vessel 10. The invention <u>"Improved Pressure Vessel"</u> of Figure 4 and its alternative embodiments in the figures subsequent to [figure] <u>Figure</u> 4 [is] <u>are</u> for a pressure vessel capable of withstanding elevated hydrostatic pressures, and elevated temperature. The pressure vessel <u>10</u> provides a protected envelope for a variety of components such as fiber optic components including items such as optical couplers, wavelength dependent multiplexers, multi-function integrated optical components, interferometers such as Mach-Zhender and Michelson types, optical sources, optical amplifiers and electronic components for signal

conditioning and acquisition as the application might require. In such applications, the components are kept at atmospheric pressure. The leads, electrical or optical are sealed in a plug at the ends of the vessel. In down-hole applications, the hose or tube 8 of Figure 3 has an inside diameter that imposes a budget on the outside diameter of any pressure vessels used for components within its interior. A typical maximum diameter for a pressure vessel might be slightly less than 0.2 inches for a down hole application.

The paragraph beginning on page 3, line 27, has been amended as follows.

Fiber optic leads or pigtails 11a and 11b exit cap 12. The pressure vessel <u>10</u> has a tubular casing 14, typically fabricated from steel that is capable of withstanding extreme hydrostatic pressures.

The paragraph beginning on page 3, line 30, has been amended as follows.

Figure 5 is a sectional view of a first embodiment of the pressure vessel 10 taken on section line A – A of Figure 4. Figure 5 shows that [the] tubular casing 14 has an internal cavity 16 and with an opening 18 in at least one end. The length of the internal cavity 16 [is characterized by a bracket below] <u>is shown by a bracket 16 below</u> the internal cavity. In the embodiment of Figure 5, the opening 18 is at the left end of the tubular casing 14. [The opening permits] <u>The opening 18 permits</u> access to said internal cavity 16. The internal cavity 16 has a hollow interior identified by bracket 20, and a plug region, having a position and length identified by bracket 22. The plug region is near the opening 18. A plug 24 is shown filing the plug region 22. Block 26 represents an electrical or optical component in the hollow interior 20. The component 20 has at least a first lead 28a, 28b passing through said plug to exit the pressure vessel as leads 11a, 11b. The plug 24 is shown encapsulating, the component leads 28a, 28b as they pass through the plug region to the opening 18 and the plug 24 seals the opening 18.

The paragraph beginning on page 4, line 11, as been amended as follows.

As shown in Figures 5 – 7, the plug 24 is cast within the plug region <u>22</u> of the tubular casing 14 of a hard incompressible material such as a loaded epoxy resin or a ceramic adhesive. The plug <u>24</u> is circular in cross section because the tubular casing <u>14</u> is circular in cross section. It should be understood, that circular cross section tubing has

an advantage over other form factors at high pressure; however, if pressure and size permitted, alternative form factors could be used such as rectangular or triangular depending on the application and the requirements.

The paragraph beginning on page 4, line 22, as been amended as follows.

Figure 7 is another alternative embodiment. [a] A plug 24 is cast in the internal cavity 16 plug region 22 in which at least a portion of the plug region 22 [is shown by] has a necked down region identified by bracket 32 as having a cross section diminishing in diameter with distance from the opening 18. The internal cross section of the internal [cavity 18 is first enlarged along] cavity 16 has a first enlarged region 33 along a first portion of the plug region 22. The plug region is then shown necked down in diameter along [a second portion 32] the necked down region 32 of the plug region 22. The necked down region 32 is followed by the hollow interior identified by bracket 20. The function of the necked down region is to drive the material of the plug into compression as the external hydrostatic pressure on the vessel increases. The diminishing portion or necked down region prevents the plug from moving into the hollow interior [18] 20. Shoulder 34 in Figure 6 provides a similar function. In the embodiment of Figure 7, the plug region is shown to be necked down to a diameter that is a match for the diameter of the [internal cavity 14] hollow interior 20 circular cross section. The irregular surface region 30 is shown positioned within the first enlarged region 33.

The paragraph beginning on page 5, line 3, as been amended as follows.

In each of the embodiments, of Figures 5 – 7 and 9 – 10, the lead exiting the opening is at least a first optical fiber having an optical core covered by optical cladding. The cladding is covered by a protective plastic jacket. The jacket over the cladding is treated to remove the jacket over the desired portion using chemical or mechanical methods. The jacket is removed from a portion of the lead after [leaving the component identified by phantom ellipse 36, through a portion passing through the plug] the lead leaves the component. The portion of the jacket to be removed begins at phantom ellipse 36, and continues through a portion passing through the plug 24 to a point just below the outer surface of the plug identified by ellipse 38. The jacket is removed to permit the

plug material to bond to the surface of the cladding which further perfects the hydraulic seal.

The paragraph beginning on page 5, line 12, as been amended as follows.

The cap 12 is formed from a polymer material to cover and extend beyond the external surface of the plug <u>24</u> thereby forming a fluid barrier over the surface of the plug <u>24</u>. Liquid Viton, a fluorocarbon elastomer, a rubber-like material, that holds at high temperature, is applied to the top or exposed surface of the ceramic adhesive to form cap 12.

The paragraph beginning on page 5, line 17, as been amended as follows.

Figure 8 is an elevation view of the pressure vessel [12] <u>10</u> having two openings in the tubular casing 14. The openings at the left and right ends permit access to the [internal cavity] <u>hollow interior 20</u>, the extent [if] <u>of</u> which is identified by bracket [16] <u>20</u> in Figure 9, a sectional view taken on line B – B of Figure 8. The internal cavity 16 has a hollow interior [the extent of which is characterized] <u>identified</u> by bracket 20.

The paragraph beginning on page 5, line 22, as been amended as follows.

Figure 9 shows a first and second cylindrical plug 46, 48 more clearly identified in Figures 10a and 11a respectively. The first and second plugs are force fit <u>via first and second plug region or internal cavity openings 18a and 18b</u> into first and second plug regions identified in Figure 9 by brackets 40 and 42 [near each of the respective openings 18a, and 18b] in the tubular casing 14. A component 26 is shown in the hollow interior 20. The component has [at least a first lead 28a, 28b] <u>at least a first and or a second lead 28a, 28b</u>.

The paragraph beginning on page 5, line 27, as been amended as follows.

Each plug has an outer cylindrical surface 50, 52, the respective outer cylindrical surface <u>50, 52</u> of each plug is force [fit into the plug] <u>fit via the plug</u> region opening 18a, 18b of the cylindrical casing 14[a] <u>into respective first and second plug regions 40, 42</u>. As shown in Figures 10a and 11a, each plug 46, 48 has a through-hole 56, 58 that receives and passes at least the component first and or second lead 28a, 28b to a position outside of the pressure vessel 10. <u>Each plug also has a first O-Ring 44a, 44b to create a</u>

seal between the inner wall of the tubular casing 14 and the respective cylindrical plug outer cylindrical surface 50, 52.

The paragraph beginning on page 6, line 15, as been amended as follows.

[Although not shown, plugs 46, 48] In the embodiments of Figures 9 - 12, the through-holes 56, 58 in the first and second cylindrical plugs 46, 48 have an inner surface. A portion of each inner surface identified by dash lines in Figures 9, 10a and 11a is formed to have an irregular or roughened surface region for improved bonding with the ceramic adhesive plug. The irregular surface of the through-hole is a functional equivalent to the [surface] irregular surface region 30 in Figure 5 under bracket 30.

The paragraph beginning on page 7, line 3, as been amended as follows.

A strain relief in the optical fiber is also necessary to protect the component from strain that results from the thermal expansion of the steel tubular casing 14 over a temperature rise to 200 degrees C. The length of the fiber strain relief on the right and left sides of component 26 are basically the same. It is important [is] that the strain [relief's] reliefs are sufficiently compliant, so that as the temperature changes and the steel expands or as pressure forces contraction, the fiber is not torn out of the component.

The paragraph beginning on page 7, line 9, as been amended as follows.

Figure 12 shows plug 62 using a second O-ring 64. The plug 62 extends beyond the ends of the tubular casing 14 and is increased in diameter to form a cap lip that is driven against the edge of the tubular casing with increasing pressure.

The paragraph beginning on page 7, line 12, as been amended as follows.

Figures 8 and 12 show the use of shrink tubing 68 over the end of the lip and the tubular casing to improve the seal of the joint formed at the interface of the lip and the end of the tubular casing, with increasing pressures.

The paragraph beginning on page 7, line 29, as been amended as follows.

The invention high-pressure vessel is the first to address the needs of the oil industries for a sensor that will withstand 10,000 psi and a temperature up to 200 degrees. No coupler produced before can meet the requirements imposed by the down-hole

drilling application. Slight movement of the fibers does not change the performance of the coupler. Temperature change does change the performance of the coupler. The gases and chemicals in the hole <u>can</u> destroy the coupler. This package protects the coupler from those materials.

The paragraph beginning on page 8, line 4, as been amended as follows.

The [package] <u>pressure vessel 10</u> is <u>typically</u> placed in a liquid filled hose <u>such as the hose 8 depicted in Figure 3</u>. The hose is filled with a material similar to transformer oil. The hose is armored and sealed. The oil filling the hose prevents it from collapsing. The region in the hose in which the component is positioned has a hydrostatic pressure roughly equivalent to that of the region outside of the hose. The couplers are used with sound sensors such as Mach-Zehnder or Michelson interferometers that are outside of the package, however, if protection for these components is required in alternative application, the invention package can be adapted to accommodate the requirement of the larger component. Four couplers are typically used with each interferometer. Two are used with the sensor and two more with the telemetry. When an array of sensors are used, two couplers are used with each sensor.

The paragraph beginning on page 8, line 18, as been amended as follows.

[If the strain relief is coiled] <u>Referring again to Figure 12, if the strain relief 70 is coiled</u>, the radius of the bend must be large enough to prevent evanescent light from escaping through the cladding. [The hose in the present application had a one-inch inside diameter hose.] <u>A hose used in a test of the subject pressure vessel 10 had a one-inch inside diameter.</u> The outside diameter of the pressure vessel was limited to 3/16 inches. The vessel length was limited to 2 1/8 inches. The inside diameter of the body was 0.118 inches. The wall thickness was 0.035 inches. The steel used was 4130. It proved to have the strength necessary to enable the vessel to pass the deformation test at 10,000 psi. It was the strongest standard tubing that was conveniently available. The cap was made of the same material. Thermal expansion was matched to that of the tubular casing in that way. Other materials could be used but at additional expense.